PATENT ABSTRACTS OF JAPAN

(11)Publication number : **09-295204**
(43)Date of publication of application : **18.11.1997**

(51)Int.CI. **B23B 27/14**
C23C 14/06

(21)Application number : **08-131050**
(22)Date of filing : **26.04.1996**

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(54) SURFACE COATING THROW AWAY INSERT

(57)Abstract:
PROBLEM TO BE SOLVED: To keep the sufficient adhesiveness of a film even in a cutting process of a steel, of which hardness is higher than the Rockwell hardness at 40 (scale C), by setting the diffraction intensity of a surface (200) at the time of X-ray diffraction of a coating layer at a value larger than a value of the diffraction intensity of a surface (111).
SOLUTION: Surface of a throw away insert is coated with the compound nitride of Ti and Al, carbon nitride, and carbide. In this throw away insert, in the case where diffraction intensity of a surface (111) at the time of X-ray diffraction of a coating layer is expressed with I (111) and diffraction intensity of a surface (200) is expressed with I (200), both the diffraction intensity are set so that a value of I (200)/I (111) becomes 1 or more. For example, a compact arc ion plating device is used so that coating of a film of (Ti0.5Al0.5) N is performed at 5μm of thickness in the condition of bias voltage at 60 V, vacuum degree at 2.0× 10-2mbar, arc current at 150 A. A coating layer at 1.5 of I (200)/I (111) is thereby formed.

LEGAL STATUS

[Date of request for examination]	31.07.1997
[Date of sending the examiner's decision of rejection]	19.10.1999
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3229947
[Date of registration]	14.09.2001
[Number of appeal against examiner's decision of rejection]	11-18614
[Date of requesting appeal against examiner's decision of rejection]	18.11.1999
[Date of extinction of right]	

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the covering slow away insertion which is rich in deficit-proof nature and a peeling resistance.
[0002]
[Description of the Prior Art] There are much reports which checked the aluminum addition effect to a TiN coat so that each official report of JP,4-53642,B and JP,5-67705,B may see Ti and aluminum in ancient times about the hard covering member which carries out a principal component. However, in these invention, the oxidation-resistant improvement in the coat by aluminum addition and an improvement of coat physical properties do not pass to have accepted, but it has come to obtain the adhesion of the coat fully satisfied in a covering slow away insertion. especially -- recently -- metal mold -- the tool life which the inclination processed in processing after metal mold's heat-treating is strong, it is easy to generate exfoliation of a coat during cutting in the slow away insertion which makes conventional Ti and conventional aluminum a principal component when processing the high degree-of-hardness steel after heat treatment, and a tool life is determined by exfoliation, and is satisfied has come to be acquired
[0003]
[Problem(s) to be Solved by the Invention] this invention person etc. came to find out the following facts, as a result of repeating that such a trouble should be solved] research wholeheartedly in cutting evaluation of the high degree-of-hardness steel exceeding Rockwell hardness 40 (C scale weighting) that the adhesion of a coat should be improved.
[0004]
[Means for Solving the Problem] The 1st knowledge which resulted in this invention is in the point which found out that the optimal coat design should change with differences of a cutting mechanism in each, although various tools, such as a slow away insertion, an end mill, and a drill, are used when processing metal mold. In a slow away insertion, in high degree-of-hardness steel cutting, generally feed per tooth exceeds 0.1mm in many cases, especially it is [cutting stress is very high and] easy to generate exfoliation of a coat. Furthermore, a cutting temperature amounts to 800 degrees C or more, it is the feature that the elevated-temperature physical properties of a coat determine a tool life, and since the edge of a blade becomes an elevated temperature, of course, the oxidation resistance of a coat also serves as an important factor. Therefore, in cutting by the slow away insertion of high degree-of-hardness material, making the adhesion of a coat, elevated-temperature physical properties, and oxidation resistance improve based on these knowledge will improve a tool life sharply.
[0005]
[Function] To the 1st knowledge, the orientation of the field in the X diffraction (200) of a coat sticks the 2nd knowledge to a coat, and it is in the point which found out governing elevated-temperature physical properties and oxidation resistance. That is, it followed on the orientation of a field (200) becoming stronger than the orientation of a field (111), the diameter of a columnar grain of a coat became large, and the conclusion that it was possible to raise the toughness in a room temperature was obtained. With very high impulse force in case a slow away insertion collides with a workpiece, exfoliation of a coat originates in internal destruction of a coat, and is generated in many cases. When a slow away insertion bit **-ed material, since temperature was comparatively low, raising the toughness in the room temperature of a coat suppressed internal destruction of a coat, and it found out the very important thing to raising the adhesion of the coat which is one of the requirements to the above-mentioned high degree-of-hardness material cutting. Furthermore, the total grain-boundary area in a coat can be decreased by making a field (200) carry out orientation of the coat by the above-mentioned diameter of columnar-crystal crystal grain big and rough-ization.
[0006] According to this invention person's etc. research, going on through a grain boundary is checked and advance of oxidization of a coat cannot be overemphasized by that it is very important to decrease grain-boundary area to the oxidation-resistant improvement in the coat which is another requirement over high degree-of-hardness material cutting. Furthermore, when a coat carries out orientation to a field (200), the knowledge whose defect in a grain boundary decreases has been acquired, and it is considered also with making the oxidation resistance of a coat improve further that there are few these defects. Moreover, making a columnar grain turn big and rough suppressed generating of the plastic deformation of a coat in the elevated temperature, and the knowledge of raising hot hardness as a result was acquired. It is possible to improve sharply the elevated-temperature physical properties which are another requirement in high degree-of-hardness material cutting by this.
[0007] The 3rd knowledge which resulted in this invention is the point which found out that it was possible to raise the adhesion

of a coat further by using the nitride of Ti, and a charcoal nitride as an interlayer between the nitrides of Ti and aluminum, the charcoal nitrides, carbide coats, and bases which carry out orientation in an above-mentioned field (200). When carrying out the vacuum evaporationo of the coat which generally contains aluminum by the physical vapor deposition, especially the arc ion plating method, since the melting point of aluminum is low, the big and rough particle which was rich in aluminum component disperses from a target, and is in the inclination which worsens field granularity of a coat. It is in the improvement in adhesion that avoiding such reduction in the stage in early stages of [coating] a base, and forming a precise coat prepares the interlayer who consists of the nitride which makes a principal component Ti which is effective to the improvement in adhesion and does not contain aluminum, and a charcoal nitride better for taste, and it becomes resulting. The probability that the coat containing Ti and aluminum will grow epitaxially to an interlayer is high, and makes adhesion improve further by using the interlayer who did orientation to the field similarly (200) to the coat containing Ti and aluminum which carried out orientation to the field especially (200).

[0008] By suppressing generating of heat at the time of the above-mentioned cutting, the 4th knowledge which resulted in this invention is in the point which found out that it was possible to raise a tool life further. Generally the compound nitride of Ti and aluminum, a charcoal nitride, and carbide had coefficient of friction as high as 0.40-0.45 to steel, according to research of this invention person from whom the edge of a blade tends to become an elevated temperature at the time of cutting, by making these coats contain oxygen, reduction of coefficient of friction was able to be attained and improvement in the further tool life by reduction of cutting heat was able to be checked by using for an outermost layer of drum. Furthermore, reduction of coefficient of friction can be further measured in order of the charcoal nitride of Ti, a carbonic acid nitride, and the oxide of aluminum, and it came to accept improvement in much more tool life by using these coats for an outermost layer of drum. Furthermore, by carrying out the lap of the front face of a coat mechanically, and setting surface roughness to 1 micrometer or less, reduction of coefficient of friction is still more possible, and it is possible to raise a tool life.

[0009] The 5th knowledge which resulted in this invention is in the point which enabled much more oxidation-resistant improvement by transposing one sort or two sorts or more of components to the compound nitride of Ti and aluminum, a charcoal nitride, and carbide in 0.05at% to 60at(s)% to Ti among Zr, Hf, Y, Si, W, and Cr. While it is possible for the result of the grain boundary to be limited by addition of these components, and to suppress the oxidation rate of a coat, it is able for the oxide layer formed on a coat front face during cutting to serve as more precise structure, to suppress diffusion inside [of oxygen] a coat, and to make the oxidation rate of a coat very late. About these reasons, it is under research further.

[0010] When, as for the 6th knowledge which resulted in this invention, the adhesion force (sigma1) of the coat on the appearance to the exfoliation generated during cutting makes sigma2 the adhesion force of a base material-coat interface, and sigma3 residual compression stress sigma1=sigma2-k-sigma 3 (k is a constant)

It is in the point which came out and found out what is expressed. Therefore, since it will see if the residual stress of a coat is too high, and the upper adhesion force declines, controlling residual stress in a certain range prevents degradation for the adhesion of a coat.

[0011] Next, the reason for having carried out numerical limitation is explained. (200) if the orientation of a field (111) becomes strong and, as for the reason for having made I (200)/I (111) or more into one, this value is less than 1, when diffraction intensity of the diffraction on-the-strength I (200) (111) side of a field is set to I (111) -- the particle size of a columnar-crystal layer -- fine -- becoming -- degradation of room temperature toughness, oxidation-resistant degradation, and an elevated temperature -- in order to bring about an advanced fall, it carried out to

[0012] The thickness of a nitride and a charcoal nitride layer was ineffective to the adhesion improvement in it being less than 0.05 micrometers, and it also set to 0.05 micrometers or more 5 micrometers or less Ti used as an interlayer in order to spoil the abrasion resistance of the whole coat, if 5 micrometers is exceeded. By below 0.05 atom %, components, such as Y added for oxidation-resistant improvement, were made below into 60 atom % more than 0.05 atom % in order to degrade abrasion resistance, if the effect over oxidation resistance replaces Ti exceeding 60 atom % few.

[0013] When 5GPa was exceeded, adhesion was less than required ** in the service condition of a slow away insertion, and since it became it easy to generate a heat crack to be 1 or less GPa, residual compression stress could be 5 or less GPa more than per GPa. Hereafter, this invention is explained based on an example.

[0014]

[Example]

In the conditions shown in Table 1 using an example 1 small arc ion plating system, it coated so that it might become the thickness of 5 micrometers about the compound nitride of Ti and aluminum, and a charcoal nitride.

[0015]

[Table 1]

試料番号		コーティング条件 バイアス電圧 V	真空度 mbar	アーク電流 A	皮膜	I(200)／I(111)	残留応力 GPa	切削可能距離(m)（剥離発生距離）	備考
本発明例	1	60	2.0×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)N	1.5	5.2	2.2m (2.1m)	
	2	60	3.0×10^{-2}	150	〃	6.7	4.8	2.8m (2.5m)	
	3	40	2.0×10^{-2}	150	〃	8.1	4.2	8.8m (8.5m)	すくい面ランド
	4	40	3.0×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)N	10.2	3.9	3.9m (3.5m)	
	5	40	0.5×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)N	6.0	5.8	2.0m (1.7m)	
	6	30	2.0×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)CN	15.4	2.5	4.2m (4.0m)	
	7	20	2.0×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)N	22.5	1.2	3.3m (3.3m)	
比較例	8	60	0.5×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)N	0.8	6.1	1.0m (0.8m)	
	9	100	2.0×10^{-2}	150	〃	0.7	5.5	0.9m (0.9m)	
	10	100	3.0×10^{-2}	150	〃	0.9	4.8	0.8m (0.7m)	
	11	150	2.0×10^{-2}	150	〃	0.2	7.2	0.1m (0.1m)	
	12	100	0.5×10^{-2}	150	(Ti$_{0.6}$Al$_{0.4}$)N	0.1	6.8	0.2m (0.1m)	

[0016] The possible cutting distance to exfoliation generating when carrying out milling cutter cutting of the obtained insertion in the following conditions was written together to Table 1. With the size of equipment etc., the coating conditions shown in Table 1 do not carry out correspondence to the value of I (200)/I (111), and 1 to 1. Moreover, by ** material SKD 61 (HRC45)-ed and cutting-speed:100m/, a cutting item is sent and are :0.1mm /, edge, amount:of slitting2.0mm, and insertion configuration:SEE42TN (G9). from Table 1, this invention covering slow away insertion I (200)/whose I (111) is one or more is boiled markedly, and an effective thing is accepted to exfoliation

[0017] It coated so that it might become the coat structure shown in Table 2 using the experiment equipment used in the example 2 example 1. Thickness was unified into 5 micrometers. The same cutting evaluation as an example 1 was performed, and the tool life was evaluated. The result is written together to Table 2.

[0018]

[Table 2]

試料番号		中間層 (μm)	TiAl層	最外層	I(200)／I(111)	切削可能距離(m)（剥離発生距離）
本発明例	13	TiN (0.4μm)	(Ti$_{0.6}$Al$_{0.4}$)N (4.6μm)	-	1.5	4.5m (4.2m)
	14	TiN (0.4μm)	(Ti$_{0.6}$Al$_{0.4}$)N (4.1μm)	TiCN (0.5μm)	7.2	7.8m (7.6m)
	15	TiN (0.4μm)	(Ti$_{0.6}$Al$_{0.4}$)N (4.4μm)	TiCN (0.5μm)	6.8	6.0m (5.5m)
	16	TiCN (0.4μm)	(Ti$_{0.6}$Al$_{0.4}$)N (4.1μm)	(TiAl)NO (0.5μm)	5.2	6.2m (6.0m)
	17	TiN (0.4μm)	(Ti$_{0.6}$Al$_{0.4}$)N (4.1μm)	Al_2O_3 (0.5μm)	12.5	10.1m (9.8m)
	18	TiN (0.4μm)	(Ti$_{0.6}$Al$_{0.4}$)N (4.1μm)	Al_2O_3 (0.5μm)	7.0	9.6m (9.5m)
比較例	19	TiN	(Ti$_{0.6}$Al$_{0.4}$)N	-	0.8	1.5m (1.2m)
	20	TiN	(Ti$_{0.6}$Al$_{0.4}$)N	TiCN	0.8	1.9m (1.6m)
	21	TiN	(Ti$_{0.6}$Al$_{0.4}$)N	TiCN	0.7	1.8m (1.5m)
	22	TiN	(Ti$_{0.6}$Al$_{0.4}$)N	(TiAl)NO	0.1	0.6m (0.4m)

[0019] From Table 2, raising a tool life further is admitted by preparing an interlayer or an outermost layer of drum in this

invention alloy which has one or more I(200)/I (111) values. Moreover, aluminum 2O3 is the most effective as an outermost layer of drum. aluminum 2O3 of this example forms 0.5 micrometers of TiAl layers by the plasma CVD after coating.

[0020] N (TiAlX) coat of the various composition shown in Table 3 using the experiment equipment used in the example 3 example 1 was created. 750 degrees C of coated test pieces were held for 30 minutes all over the air furnace, and the thickness of the formed oxidizing zone was measured. The result is also written together to Table 3.

[0021]

[Table 3]

	試料番号	皮膜組成	酸化膜厚(μm)
本	23	(Ti0.48Al0.5Y0.02)N	0.7
発	24	(Ti0.47Al0.48Cr0.05)N	0.9
明	25	(Ti0.48Al0.5Zr0.02)N	0.7
例	26	(Ti0.28Al0.5Y0.28)N	0.1
	27	(Ti0.28Al0.5Zr0.28)N	0.5
	28	(Ti0.4Al0.5W0.1)N	0.8
	29	(Ti0.4Al0.5Si0.1)N	0.1
	30	(Ti0.48Al0.5Si0.02)N	0.2
	31	(Ti0.4Al0.5Hf0.1)N	0.9
	32	(Ti0.3Al0.5Y0.1Si0.1)N	0.05
比	33	(Ti0.4Al0.6)N	1.8
較	34	(Ti0.4Al0.5Nb0.1)N	2.5
例	35	(Ti0.4Al0.5Ta0.1)N	3.3

[0022] An oxidation-resistant improvement of a coat is possible by addition of Y, Si, W, Cr, Zr, and Hf so that clearly from Table 3.

[0023]

[Effect of the Invention] By applying this invention, the adhesion of sufficient coat can be maintained also in cutting of the high degree-of-hardness steel exceeding Rockwell hardness 40 (C scale weighting), and it can apply to various tools, such as a face cutter which used the slow away insertion applied when processing metal mold, an end mill, and a drill.

[Translation done.]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] Surface coating [to which the value of I (200)/I (111) is characterized by the bird clapper one or more] slow [when I (111) and diffraction intensity of a field (200) are set to I (200) for the diffraction intensity of the field in the X diffraction (111) of an enveloping layer in the slow away insertion which covered the compound nitride of Ti and aluminum, a charcoal nitride, and carbide] away insertion.
[Claim 2] The surface coating slow away insertion characterized by using as an interlayer the nitride of Ti which has 0.05-micrometer or more thickness 5.0 micrometers or less between a base, the compound nitride of Ti and aluminum, a charcoal nitride, and a carbide enveloping layer, and a charcoal nitride in a surface coating slow away insertion according to claim 1.
[Claim 3] surface coating slow away one a claim 1 and given in two -- insertion **** -- the surface coating slow away insertion characterized by covering one sort of monolayers, or two or more sorts of tectostratums further on the compound nitride of Ti and aluminum, a charcoal nitride, and a carbide layer among the charcoal nitride of Ti, a carbonic acid nitride, the compound nitric oxide of Ti and aluminum, a carbonic acid nitride, a carbonation object, an oxide, and the oxide of aluminum
[Claim 4] The surface coating slow away insertion characterized by transposing the one section of Ti to one sort or two sorts or more in Zr, Hf, Y, Si, W, and Cr in the range below 60 atom % more than 0.05 atom % to Ti in a surface coating slow away insertion according to claim 1 to 3.
[Claim 5] The surface coating slow away insertion whose compressive stress which remains to the compound nitride of Ti and aluminum, a charcoal nitride, and carbide in a surface coating slow away insertion according to claim 1 to 4 is characterized by being more than 1Gpa5Gpa.
[Claim 6] The surface coating slow away insertion characterized by setting field granularity by the side of the rake face of a slow away insertion to 1 micrometer or less in a surface coating slow away insertion according to claim 1 to 4.

[Translation done.]